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Analysis of Morphology Characters on Fuse Residuum of Knife Switch in Fire Ground

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Abstract

In this paper, the integrated experimental system of material evidence for fire trace was used to make fuse residuum by simulating overload and short circuit of electric circuit, bad connection and fire. The scanning electron microscope can be utilized to observe and analyze the morphology characters on fuse fesiduum. The results indicate that in the condition of the overload and short circuit of electric circuit, bad connection and fire, the melted trace,s morphology is different, besides the amount of the oxide on the fuse residuum's surface is various. When the electric circuit is overload, there is no port in the fuse fesiduum. But there is some bled in the fuse fesiduum of the short circuit and fire. The dimple of fuse fesiduum is different.

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Keywords: knife switch, fuse, fesiduum, morphology characters

1. Preface

The number of electrical fire is high. And it brings huge economic losses and major casualties every year. For example, there is about 45703 electrical fire in 2007, making up 28.8% of the total in China. There is about 40000 electrical fire in 2008, making up 30.1% of the total in China. And the proportion of 2008 is higher than that of 2007 [1~4]. Many electrical fire is related to the fuse of knife switch. The main reasons of fuse residuum of knife switch are electric circuit, bad connection and fire. In order to judge the reasons for the formation of the fuse of knife switch, the integrated experimental system of material evidence for fire trace was used to make fuse residuum by simulating overload and short circuit of electric circuit, bad connection and fire in the paper. The scanning electron microscope can be utilized to observe and analyze the morphology characters on fuse fesiduum. The paper compares the images of fuse fesiduum and analyze characteristic morphology in order to put forward the method of estimate the reasons for the formation of the fuse of knife switch.

2. Experiment

2.1. Equipment and materials

KYKY-2800B scanning electron microscope, the integrated experimental system of material evidence for fire trace, the fuse of 5A rated current, the fuse of 10A rated current, the fuse of 10A rated current.

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2.2. Sample preparation

(1) The preparation of fuse overload residues

The first is to feed the fuse into knife switch. The second is to set the current in the circuit for 2 times, 2.5 times, 3 times, 3.5 times, 4 times of the rated current by adjusting the voltage regulator; Finally, we get the different fuse fesiduum at different current load.

(2) The preparation of fuse short-circuit residues

Using the same method with the preparation of fuse overload residues, we get different fuse fesiduum at different short-circuit current.

(3) The preparation of fuse bad connection residues

The one of the fastening bolt that is connected to the fuse is tighten up, the other is slack. Then using insulators make fuse keep touching bolt. Finally, we get different fuse fesiduum at the condition of bad connection.

(4) The preparation of fuse burning residue

A long fuse is fixed on the liquefied gas oven and fired. Then we get different fuse fesiduum on fire.

The scanning electron microscope can be utilized to observe and analyze the morphology characters on fuse fesiduum.

3. Result and analysis

3.1. Analysis of morphology characters on fuse overload residuum of knife switch

When overload, the current is relatively much smaller. Fuse gradually heats up, and after a period of time, fuse melts and disconnects. This phenomenon is called “fusing”. So the quantity of fuse defect is little. According to the skin effect of current, when the fuse have alternating current, the surface current density of fuse will increase and the joule heat of fuse surface is more. The surface of fuse melts and curdles.But the center part of the fuse has not melted and curdled yet when the process of overload has ended. So the end region of fusing area remains pointed melt that does not melt. At the same time the fuse appears shriveled, as shown in Fig 1(a). At high power, the surface of fuse is rough. And there are traces of melt flow and a large number of oxide on the surface. The instantaneous temperature of overload and environmental temperature are different. It forms a great difference in temperature. It causes liquid metal shrink rapidly. The process of shrinkage is short. Liquid cannot be gotten effectively. So it forms shrinkage cavity, as shown in Fig 1(b). Fuse belongs to the alloy material whose plastic is good. Its fracture cup appears cone shaped. And it appears plastic deformation obviously, as shown in Fig 2(a). At high power, there are isometric dimple. The dimple’s diameter is small, but the dimple is deep. There are spiral textures inside the dimple, as shown in Fig 2(b). In general, the larger the plastic of the material is, the more obvious the phenomenon of neckingis. So the larger the plastic of the material is, the deeper the dimple is [5].

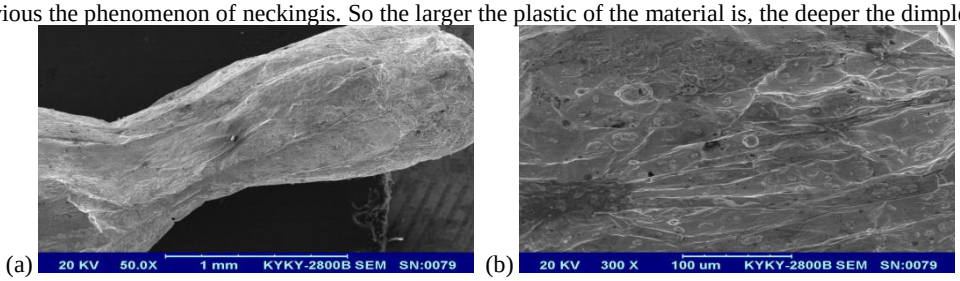

Fig.1. Illustration of Surface morphology characters on fuse overload residuum of knife switch for (a)low power and (b)high power

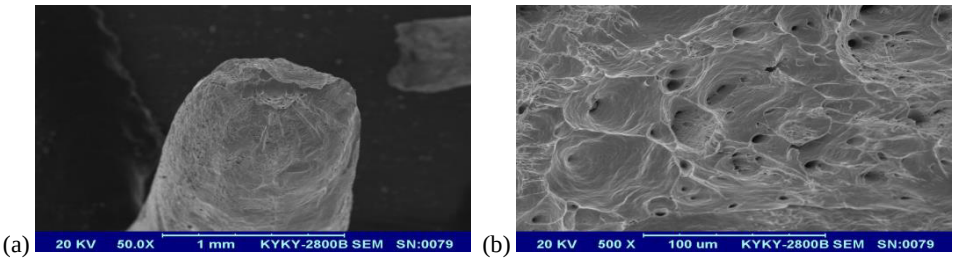

Fig.2 Illustration of Sectional morphology characters on fuse overload residuum of knife switch for (a)low power and (b)high power

3.2. Analysis of morphology characters on fuse short-circuit residuum of knife switch

When fuse is short-circuit, the instantaneous current that is through the fuse is large. The temperature of the fuse rise rapidly. The fuse melts rapidly and may be gasification. It is called “blast off “. So the quantity of fuse defect is much. The fusing marks of the fusing area appears arc that is smooth. The end region of fusing area is little thicker than noumenon, as shown in Fig 3(a). The temperature of short-circuit is high, but the duration is short. The oxide that is on the surface is less, so the surface is smooth, as shown in Fig 3(b). The cooling rate is rapid. And the process of the solidification is shorter. The gases that are absorbed by the fuse when it is melted have no time to escape. So the gases are trapped in the internal organization of the fuse. The fracture is rough. It appears honeycomb. The fracture has obvious macroscopic plastic deformation, as shown in Fig 4(a). The pattern appears parabolic. When fuse is short-circuit, the temperature of the fuse is high. So crystal boundary is oxided. It makes the plastic of the fuse reduced. The dimple’s diameter is big, but the dimple is shallow, as shown in Fig 4(b).

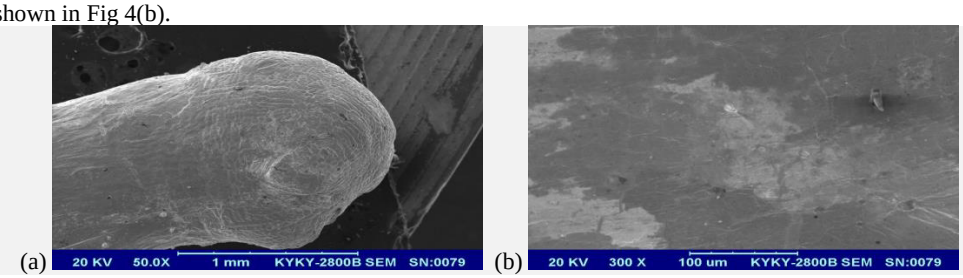

Fig.3 Illustration of Surface morphology characters on fuse short-circuit residuum of knife switch for (a)low power and (b)high power

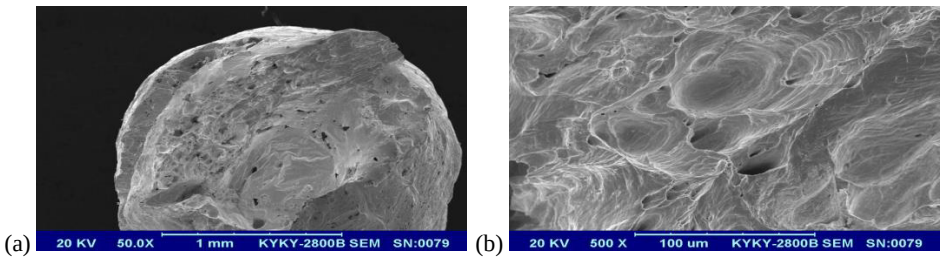

Fig.4 Illustration of Sectional morphology characters on fuse short-circuit residuum of knife switch for (a)low power and (b)high power

3.3. Analysis of morphology characters on fuse bad connection residuum of knife switch

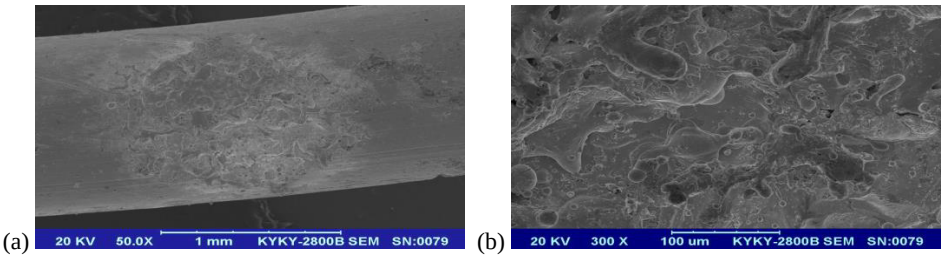

Fig.5 Illustration of Morphology characters on fuse bad connection residuum of knife switch for (a)low power and (b)high power

The time of bad connection is short. The current of fuse is so smaller that fuse cannot break. There are only weld marks on fuse. The junction that is between fuse and spiral often strikes a light. There are ablation marks on the surface of fuse. There are also pits on the junction, as shown in Fig 5(a). The sequence that the parts of bad connection leave screw is different. There are oxides on the part that leaves first. There are melting traces on the surface that leaves at last. Therefore, the distribution of oxide is uneven. But the oxide is relatively more, as shown in Fig 5(b).

3.4. Analysis of morphology characters on fuse burning residuum of knife switch

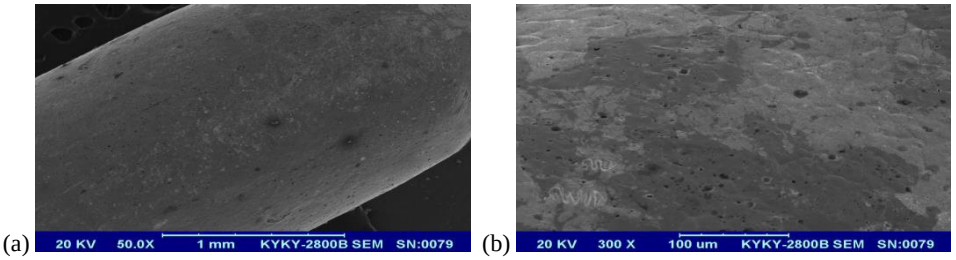

Fig.6 Illustration of Surface morphology characters on fuse burning residuum of knife switch for (a)low power and (b)high power

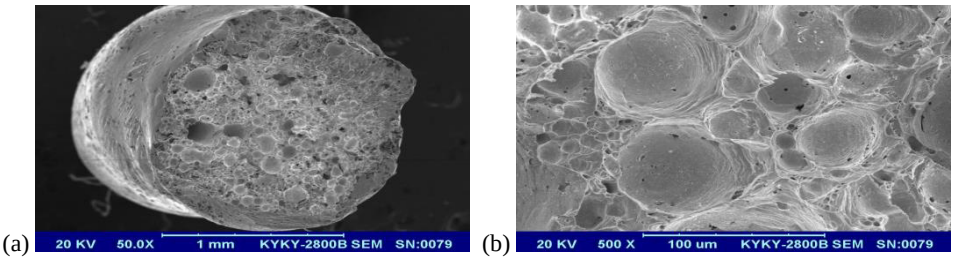

Fig.7 Illustration of Sectional morphology characters on fuse burning residuum of knife switch for (a)low power and (b)high power

The surface of fuse is smooth. The weld mark is sharp. The transition area that is between melted section and noumenon is obvious. The temperature of fire is 650 ~ 750 ℃. It is so high that the distribution of the oxides that adhere to the surface is loosen. It easily falls off. So there are seldom oxides on the surface of fuse, as shown in Figure 6(a). Because the speed of cooling is high, there are pores, as shown in Fig 6(b). The melting point of fuse is 200 ~ 300 ℃. The temperature of that is far more than that of the melting point. So the grain boundary melts. And it is oxidized. There are pits and inclusions in the internal organization of residuum. So the plastic of fuse is further reduced. The dimple is shallow, as shown in Fig.7.

4. Conclusion

It is can be identified that the formation of the fuse residue is caused overload of electric circuit, short circuit of electric circuit, bad connection or fire by simulated experiment.

（1）The residue's surface of overload of electric circuit, short circuit of electric circuit, bad connection and fire by simulated experiment is different. When the electric circuit is overload, the surface appears shriveled. When the electric circuit is short circuit, the end region of fusing area is little thicker than noumenon. There are pits on the surface of bad connection. When the fuse is on fire, the weld mark is sharp. The amount of the oxide on the fuse fesiduum,s surface is various, the sequence is short circuit, fire, overload, and bad connection from big to small order.

（2）The section of fesiduum is obviously different. When the electric circuit is overload, there is no port in the fuse fesiduum. But there is some bled in the fuse fesiduum of the short circuit and fire. The dimple of fuse fesiduum is different, the sequence is overload, short circuit and fire from big to small order.

（3）When the electric circuit is overload, the quantity of fuse defect is little. When the electric circuit is short circuit, the quantity of fuse defect is much.

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